Ecology of Harlequin Ducks
(Histrionicus histrionicus)
in Northern Idaho

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Ecology of Harlequin Ducks (Histrionicus histrionicus) in Northern Idaho

by

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ABSTRACT

We examined the population dynamics, habitat use, and food habits of harlequin ducks breeding in northern Idaho 1989 - 1992. During 1991 - 1992, the breeding population on 7 study streams remained stable at 15 - 17 pairs and a total of 39 - 40 adult ducks. Annual productivity 1990 - 1992 averaged 1.2 ducklings fledged/female and ranged from 0.7 ducklings to 1.4 ducklings fledged/female. Median hatching date was June 18 (range June 15 - July 1). Fledging occurred at 41 - 63 days ($\underline{X}$ = 49, $\underline{n}$ = 12 broods). Brood size at fledging averaged 3.33 ducklings, with an average duckling survival rate to fledging of 55% (range 47 - 65%). Harlequin ducks were most frequently observed in western red cedar/western hemlock forest (*Thuja plicata*/ *Tsuga heterophyla*), on swiftly flowing streams less than 10m wide with a cobble to boulder substrate. Most observations were in mature or old growth forested stands that had not been logged or had an unlogged buffer along the stream. Four nests were found, 2 on canyon walls, 1 in dense vegetation on an island, and 1 in a tree cavity. Broods used significantly smaller stream reaches than adults.

Streams used by harlequin ducks in northern Idaho, northwestern Montana, and northwestern Wyoming ($\underline{n}$ = 11) were significantly more alkaline ($\underline{X}$ = 58 m/L $CaCO_3$) than northern Idaho streams not used by harlequin ducks ($\underline{X}$ = 8 m/L $CaCO_3$, p = 0.04). Average productivity from 1990 - 1992 was negatively correlated to May, June, and July streamflows (June $\underline{n}$ = 2

watersheds, 3 years, r = -0.93; P = 0.006), and appeared to be independent of benthic macroinvertebrate biomass (n = 2 streams, 2 years; P = 0.41).

Two females radio-marked in Idaho were located in the San Juan and Gulf Islands in northwestern Washington and southwestern British Columbia in July and August. One band return was also received from northwestern Washington. Return rates of marked adults to northern Idaho averaged 63%, with 89% of ducks that returned once returning in successive years. Nearly all birds returned to the same stream, and return rates were the same for males and females. Some pairs maintained multi-year pair bonds. None of 27 ducklings banded 1988 - 1992 have been reobserved in Idaho.

Continued inventory and monitoring of harlequin ducks in northern Idaho is essential for establishing baseline data and assessing effects of management actions. Timing is critical for success of an inventory or monitoring effort. In northern Idaho, pair surveys should be conducted between April 25 and May 25. Brood surveys should be conducted between July 15 and August 5. Recommended methodology and areas for inventory and monitoring are included.

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INTRODUCTION

Harlequin ducks are sea ducks that breed inland on swiftly flowing mountain streams. In North America, this holarctic species occurs in disjunct populations associated with the Pacific and Atlantic coasts. The Pacific breeding range extends through Alaska, British Columbia, Washington, Oregon, inland to the Yukon and Northwest territories, Alberta, Idaho, Montana, and Wyoming.

The harlequin is a category 2 candidate for listing throughout its range in the United States and is listed as an endangered species in eastern Canada (Cassirer et al. 1993a). Little information is available across its range on habitat use, population dynamics, or abundance. In 1987, surveys were initiated in Idaho to examine distribution and size of the breeding population. By 1990, harlequins had been found on 38 streams in northern, north-central, and southeastern Idaho. The breeding population was estimated at 100 birds or less (Cassirer et al. 1991).

This study was initiated in 1991 to better define population dynamics and habitat use, to investigate factors affecting density and productivity, and to develop inventory and monitoring protocols for harlequin ducks in northern Idaho. Separate sections of this report examine population ecology, habitat use, food habits, and factors potentially affecting productivity. The last section is an inventory and monitoring protocol for northern Idaho.

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STUDY AREA

This study was conducted on northern Idaho streams in the Priest Lake, Upper Priest Lake, and southeastern Lake Pend Oreille watersheds. These areas are primarily managed by the Priest Lake and Sandpoint Ranger Districts on the Idaho Panhandle National Forests, and the Idaho Department of Lands. A small amount of the area is in private ownership. Harlequin duck ecology was studied on 4 streams at Priest and Upper Priest Lakes: Upper Priest River, Hughes Fork, Gold Creek, and Granite Creek, and 3 streams at Lake Pend Oreille: Granite, North Gold and Gold Creeks. About 30-40% of Idaho's known harlequin duck

population breeds on these streams (Cassirer and Groves 1990).

An additional 9 streams in the Priest Lake watershed: S. Fork Granite, Blacktail, Tillicum, Willow, Beaver, Caribou, Lion, Two Mouth, and Soldier Creeks, and 3 streams at Lake Pend Oreille: Johnson, Cedar, and North Twin Creeks, were also surveyed at least once during the study. Habitat and invertebrate information were collected on these streams, but no harlequin ducks were observed.

POPULATION ECOLOGY

Methods

Stream Surveys.--Harlequin duck numbers and productivity were estimated from repeated surveys of the study area streams. In 1991, Gold and Granite Creeks on Lake Pend Oreille were surveyed weekly starting April 19; 1992 surveys on all streams were conducted every 10 - 14 days starting March 16. Surveys continued until the end of August or for 2 weeks after the last ducks were observed, whichever was later. Additional information is included from similar surveys conducted in 1989 and 1990.

Stream surveys consisted of walking in or along the stream with 8 or 10 power binoculars and looking for ducks. Ducklings were classified by plumage development categorized into 3 classes and 7 subclasses; from class IA downy, no feathers visible, to class III, fully feathered (Gollop and Marshall 1954).

Trapping, Marking, and Radiotelemetry.--Return rates, migration, and nesting information were collected from banded,

nasal- and radio-marked harlequin ducks. Harlequins were trapped from 1988 to 1992 by flushing them into 10-cm mesh mist nets set up across the stream. Adults were trapped with a single net stretched between poles on either bank. Ducklings were sometimes able to break through a single net when several were trapped in a group, so a double net was used for trapping broods.

All ducks were legbanded with U.S. Fish and Wildlife Service (USFWS) bands. Adults were also individually marked with colored nylon nasal disks and juveniles either nasal-marked or color leg-banded through 1991. In 1992, colored legbands were used on both adults and juveniles.

Nine females were also radiomarked in the spring before and during incubation (1991 n = 4, 1992 n = 5), and 7 females were radioed in the summer just prior to migration (1991 n = 4, 1992 n = 3). We used Holohil PD-2 (Holohil Systems Ltd., Ontario, Canada) and ATS (Advanced Telemetry Systems, Inc., Isanti, MN) transmitters. Transmitters were either attached to the base of the tail feathers with a plastic tie, or sutured behind the nape with two stitches of 3/0 nonabsorbable suture material.

Results and Discussion

Harlequin Duck Numbers.--Total number of adults on the 7 study streams was estimated at 40 in 1991 and 39 in 1992. In 1991, 15 pairs and 10 unpaired drakes were observed and in 1992, 17 pairs and 5 unpaired drakes were observed. No unpaired females were observed either year. Sex ratio of males to females

was 1.7:1 (64% males) in 1991 and 1.3:1 (55% males) in 1992. Numbers appear to have remained fairly stable since 1990, with an average of 2 or 3 pairs and 1 or 2 unpaired males per stream (Table 1).

Duckling Development.--Twelve broods were followed from hatching or class I in 1991 and 1992. Plumage development was variable among broods. In general, feathers were first visible (Class II), at 2 to 3 weeks, ducklings were fully feathered (Class III) at 5 to 6 weeks, and fledging was observed at 6 to 7 weeks. However, some ducklings were 7-weeks of age before reaching Class III and did not fledge until 9 weeks (Table 2). Fledged ducklings were as large or larger than the hen and nearly indistinguishable from an adult female in the field. In the hand, ducklings had lighter legs and feet than the hen (yellowish vs. gray), shorter wings, a darker bill with no light callous on the end and a darker face, particularly the light patch next to the bill. Overall, ducklings were slightly browner. The white dot near the ear was just as bright in ducklings as the hen. Ducklings also had new rounded tail feathers, whereas tail feathers on the hen had worn, pointed tips.

Table 1. Adult harlequin duck numbers on 7 streams in northern Idaho, 1989 - 1992.

Stream	1989		1990		1991		1992		Average	
	Pairs	Unpaired males	Pairs	Unpaired males	Pairs	Unpaired males	Pairs	Unpaired males	Pairs	Unpaired males
Granite Cr., L.Pend Oreille					2	3	1	2	1.5	2.5
Gold and N. Gold Cr., L. Pend Oreille			2	0	4	0	4	1	3.3	0.3
Granite Cr., Priest Lake	3	2	2	1	1	2	3	2	2.25	1.75
Gold Cr., Priest Lake			2	1	2	2	4	0	2.6	1
Upper Priest River			4	2	2	2	3	0	3	2.7
Hughes Fork			5	1	4	1	2	1	3.3	1
Total					15	10	17	5	16	7.5

Table 2. Harlequin duckling development in 12 broods on 7 streams in northern Idaho, 1991 - 1992.

	Hatch date	Age in days at class						
		IA (6)[b]	IB (5)	IC (9)	IIA (5)	IIB-C (9)	III (6)	Fledged (8)
Range	6/15 - 7/1	1 - 4	4 - 8	8 - 21	15 - 28	21 - 49	25 - 51	41 - 63
Median	6/18	2	7	9	21	28	43	49
Estimated average[a]		1 - 4	5 - 8	9 - 14	15 - 25	26 - 35	36 - 41	42 - 51

[a] Best estimate for aging harlequin ducklings in the field.

[b] Number of broods observed.

<u>Duckling Survival</u>.--In 1991, duckling survival from hatching or class IA to fledging averaged 65%. Survival in 1992 dropped to 47%. On average, about half the ducklings reached fledging from hatching or class IA in 1991 and 1992 (Table 3). Over half the mortality occurred during the first 3 weeks, but duckling mortality continued throughout the breeding season to fledging. Average brood size at hatching or class IA was 5. Each year, 1 brood did not have any ducklings that reached fledging. Average size of the 10 broods that reached fledging was 3.33.

From 1990 - 1992, productivity on the 6 study streams averaged 1.2 ducklings fledged per female, or an average of 10.5 ducklings fledged per year. Productivity was highly variable among years, ranging from 0.7 ducklings per female in 1991 to 1.4 ducklings per female in 1990 (Table 4). Average productivity was slightly higher at Lake Pend Oreille than in the Upper Priest River watershed, however this difference was not significant.

Table 3. Percent survival of harlequin ducklings on 7 streams in northern Idaho, 1991 - 1992.

	initial brood size	Survival rate						$\bar{x}$ brood size at fledging
		2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	Fledging	
1991 (4 broods)	4.25	0.88	0.88	0.76	0.76	0.65	0.65	3.67
1992 (8 broods)	5.38	0.82	0.65	0.62	0.61	0.53	0.47	3.14
Average 1991 - 1992	5.00	0.84	0.73	0.68	0.66	0.57	0.55	3.33

Breeding Chronology.--In 1992, the only year surveys began before ducks arrived on the breeding streams, the first harlequin duck observed was a lone male, April 1 on Upper Priest River. The first pair was observed April 20, on Granite Creek at Lake Pend Oreille. Pairs were observed both years from late April until mid-June. Males left the breeding streams significantly earlier in 1992 ($\underline{X}$ = May 18) than in 1991 ($\underline{X}$ = June 10, $\underline{P}$ = 0.03). Ducklings were observed from mid-June until early September both years (Table 5) and median estimated hatching date, June 18 did not differ among years (1991 $\underline{n}$ = 4, 1992 $\underline{n}$ = 8; $\underline{P}$ = 0.09) or between Lake Pend Oreille ($\underline{n}$ = 5) and Priest Lake streams ($\underline{n}$ = 7, $\underline{P}$ = 0.09).

Survey Accuracy.--Estimates of the maximum number of pairs using a stream in a given year were made by summing all marked pairs observed using a streams during the season with the maximum number of unmarked pairs. During pair surveys in both years, 23 (58% or 59%) of the estimated 39 or 40 adult harlequin ducks on the survey area were marked. Although observation rates on a single stream survey varied from 0 to 100%, accuracy of pair estimates from a single survey averaged 63% between April 25

Table 4. Productivity of harlequin ducks on 7 streams in northern Idaho, 1990 - 1992.

Stream	1990		1991		1992		All years	
	Total ducklings fledged	$\bar{x}$ ducklings fledged/female	Total ducklings fledged	$\bar{x}$ ducklings fledged/female	Total ducklings fledged	$\bar{x}$ ducklings fledged/female	$\bar{x}$ ducklings fledged	$\bar{x}$ (SE) ducklings fledged/female
Upper Priest River watershed (3 streams)	–[a]	1.0	8	1.0	13	1.4	10.5[b]	1.1 (0.13)
N. Fork Granite Creek (Priest Lake)	3	1.5	0	0	0	0	1.0	0.5 (0.50)
Lake Pend Oreille watershed (3 streams)	–[a]	1.5	3	0.5	9	1.8	6[b]	1.3 (0.39)
All streams	–[a]	1.4 (0.26)	11	0.7 (0.46)	22	1.3 (0.49)	16.5	1.2 (0.23)

[a] Not all streams were surveyed in 1990.

[b] Average number of ducklings fledged in 1991 and 1992.

Table 5. Chronology of harlequin duck observations on 7 streams in northern Idaho, 1991 - 1992.

Observation	1991 Date	1991 Stream	1992 Date	1992 Stream
First harlequin			4/1	Upper Priest River
First pair			4/20	Granite Creek, PDO
First duckling	6/26	Gold Creek, PL	6/19	Gold Creek, PDO
Last pair			6/8	Upper Priest River
Last male	6/26	Granite Creek, PDO	6/8	Upper Priest River
Last female without a brood	8/1	Gold Creek, PDO	7/20	Granite Creek, PL
Last duckling	9/9	Hughes Fork	9/2	Upper Priest River

and June 5 (Table 6). On average, surveys conducted after June 5, and before April 25, revealed fewer than 25% of pairs using a stream. In 1991, surveys between April 25 and May 1 had the best accuracy (67%). In 1992, surveys between May 11 and May 24 were most accurate (76%).

The highest number of ducklings was observed during surveys conducted June 20 - July 3. However, due to duckling mortality and some late hatching dates, surveys between July 4 and mid-August actually provided a more accurate indication of the number of ducklings fledged (Table 6).

Table 6. Percent accuracy of harlequin duck surveys on 7 streams in northern Idaho, 1991 - 1992.

Dates	Males		Females without broods		Juveniles		Percent pairs observed			Percent juveniles fledged observed		
	1991	1992	1991	1992	1991	1992	1991	1992	x 1991-1992	1991	1992	x 1991-1992
3/16-3/29		0		0		0		0	0		0	0
3/30-4/12		1		0		0		0	0		0	0
4/13-4/24	1	5	0	1	0	0	0	6	3	0	0	0
4/25-5/8	11	17	10	11	0	0	67	65	66	0	0	0
5/9-5/22	16	17	9	13	0	0	60	76	69	0	0	0
5/23-6/5	12	10	8	9	0	0	53	53	53	0	0	0
6/6-6/19	9	2	9	7	5	15	13	12	13	45	68	61
6/20-7/3	2	0	7	12	12	30	6	0	3	109	136	127
7/4-7/17	0	0	9	5	15	17	0	0	0	136	77	97
7/18-7/31	0	0	4	0	9	21	0	0	0	82	95	91
8/1-8/14	0	0	2	0	8	20	0	0	0	73	90	85
8/15-8/28	0	0	0	0	1	5	0	0	0	9	23	18
8/29-9/4	0	0	0	0	1	4	0	0	0	9	18	15
9/5-9/11	0	0	0	0	1	0	0	0	0	9	0	3
9/12-9/25	0	0	0	0	0	0	0	0	0	0	0	0

Migration.--Two of 7 unsuccessful or nonbreeding females radiomarked on breeding streams in early July, were relocated on the Pacific coast in late July and early August. One hen originally marked on the Hughes Fork in May 1988 was radiomarked July 17, 1991 on Upper Priest River. She was aerially relocated July 30, 1991 off Battleship Island, Washington, a National Wildlife Refuge in the San Juan Islands. On July 31, a ground location revealed her to be alone and able to fly (not molting). She returned to northern Idaho in 1992 and nested successfully on

the Hughes Fork. She was again observed on Upper Priest River during the summer of 1993.

A female radiomarked on the North Fork of Granite Creek at Priest Lake July 8, 1992 was aerially relocated July 25 and July 31, 1992 off Halibut Island in the southern Gulf Islands, British Columbia. A ground location on August 2, 1992 revealed her to be in a group of 26 molting harlequins.

One band return was received from a juvenile male marked as a duckling on the Hughes Fork in 1991. This bird was shot off a scoter decoy at Oak Harbor, Washington, in October 1992. The duck was reported to be in breeding plumage in a group of 4 harlequin ducks.

Return Rates.--Thirty-nine adults (25 females and 14 males) were marked on the study area from 1988-1992 (Appendix A). Of the 30 (19 females and 11 males) marked prior to 1992, 19 (63%) returned at least once. Return rates were equal for males and females. Of the 9 ducks that returned once and were followed for more than 2 years, 8 (89%) returned more than once. At least 1 duck marked in 1988 returned through 1993 (6 years).

Twenty-seven ducklings were marked from 1989 - 1991. None were reobserved on the streams during the study period.

Philopatry.--All ducks returned to the same area where they were marked. No exchange was observed between Lake Pend Oreille and Priest Lake, and no ducks marked at Granite Creek at Priest Lake returned to the Upper Priest River watershed during the spring breeding season. One marked female observed on Granite

Creek at Priest Lake during 1991 and 1992 was trapped on Gold Creek at Priest Lake in July of 1992, evidently just prior to or during migration. One male marked in 1990 on Gold Creek at Lake Pend Oreille was observed on Granite Creek at Lake Pend Oreille in 1991 and 1992. Several ducks moved between Upper Priest River, the Hughes Fork, and Gold Creek throughout the breeding season.

Mate Fidelity.--Six pairs were individually marked together between 1988 and 1991. One pair was not reobserved in subsequent years, and the status of a second pair following marking could not be determined because the ducks were extreme wary and several drakes were present at the few observations of the female. Two pairs remained together; 1 pair originally marked in 1988 maintained their pair bond through the entire study (through 1992), the other pair was marked in 1991 and were paired again in 1992. In 2 cases only 1 individual from the pair returned in subsequent years. In 1 pair only the male returned, and in 1 only the female returned. The female returned mated with an unmarked male. The male returned as a bachelor drake for 2 years before pairing with an unmarked female.

HABITAT USE

The harlequin is the only duck in the northern hemisphere to nest almost exclusively along swiftly flowing mountain streams. Within their breeding range, harlequin ducks nest only along a select number of clear streams with rocky substrates.

Streambank characteristics are highly variable, from moorland in Iceland (Bengtson 1972), spruce forest and willow thickets in Labrador, to coniferous forest in the Rocky Mountains (Cassirer et al. 1993a).

Methods

To quantify habitat use of harlequin ducks in northern Idaho, data on stream and streambank characteristics were collected whenever harlequin ducks were observed during systematic stream surveys 1990-1992. These data include observations on the Lochsa, St. Joe, Coeur d'Alene, and Moyie Rivers, and the East Fork of Lightning Creek in 1990 as well as on the study streams at Priest Lake and Lake Pend Oreille.

In 1991 and 1992, stream velocities were measured by throwing a fishing bobber into the center of the stream current 3 times and averaging the length of time it took to travel 5m. Percent canopy cover was estimated by averaging 4 readings of a spherical densiometer at the edge of the stream. This represents the canopy cover on the streambank, not in the interior forest. Appendix A contains a sample data sheet with an explanation of habitat classifications.

Analysis of use was based on 250 adult observations, 80 brood observations and 4 nest locations. Habitat variables were compared with chi-square tests (Neu et al. 1974) and t-tests.

Results and Discussion

Adults and Juveniles.--Adult and juvenile harlequin ducks in northern Idaho typically used streams with a cobble to boulder substrate in mature to old-growth western red cedar/western hemlock (*Thuja plicata*/*Tsuga heterophylla*) forest. Stream reaches used by harlequin ducks were usually away from roads or trails and were not logged or had an unlogged buffer along the stream. Most harlequin ducks were observed in streams 10 m or less in width; broods were observed in significantly smaller streams than adults (Table 7).

Brood habitat also differed significantly from adult habitat in several ways that could indicate selection for these characteristics or may simply reflect seasonal changes in the streams due to lower discharge at the time broods were using them. These include greater use of pocketwater and pool habitats, the presence of more loafing sites (Table 7), slower average water velocities (Adults X = 1.20 m/sec, SD 0.577, n = 164; Broods X = 0.89 m/sec, SD 0.381 n = 64; P = 0.000), and

Table 7. Comparison of habitats used by harlequin duck adults and broods (percent use) in northern Idaho, 1990 - 1992.

Classification	Adults	Broods
n	(250)	(80)
Stream habitat P = 0.000		
Riffle	20	21
Run	29	13
Rapid	25	17
Pocketwater	9	29
Pool/Backwater	17	21
Substrate p = 0.892		
Cobble	54	54
Boulder	20	22
Bedrock	4	2
Gravel/Sand/Silt	22	22
Bank composition p =0.732		
Trees	39	42
Shrubs	22	21
Mosaic	22	17
Grass/forb	7	7
Gravel/Sand/Silt/Bedrock	2	11
Woody Debris	1	2
Overstory age p = 0.018		
Old growth	20	20
Mature	58	45
Immature	16	18
Sapling/pole	3	18

Table 7 cont'd. Comparison of habitats used by harlequin duck adults and broods (percent use) in northern Idaho, 1990 - 1992.

Classification	Adults	Broods
n	(250)	(80)
Overstory species p = 0.018		
Cedar/Hemlock	82	84
Ponderosa Pine/ Douglas-fir	3	11
Spruce/Fir	13	1
Deciduous/Larch/ Lodgepole	2	4
Logging history p = 0.813		
None	90	91
Clearcut or selection harvest	10	9
Accessibility p = 0.343		
Over 50m from a road or trail	75	80
Less than 50m from a road or trail	25	20
Stream width (m) p = 0.001		
1 - 5	23	39
6 - 10	40	46
11 - 15	16	11
> 15	20	4
Channel type p = 0.436		
Straight	27	43
Curved	35	22
Meander/Braided	38	35

Table 7 cont'd. Comparison of habitats used by harlequin duck adults and broods (percent use) in northern Idaho, 1990 - 1992.

Classification n	Adults (250)	Broods (80)
<u>Loafing sites/ 10m</u> p = 0.000		
0	17	6
1	19	5
>1	64	88
<u>Woody debris/ 10 m</u> p = 0.608		
0	39	35
1	20	25
>1	41	40
<u>Bank undercut</u> p = 0.905		
Present	49	49
Absent	51	51
<u>Vegetative overhang</u> p = 0.239		
Present	61	53
Absent	39	47

warmer water temperatures (Adults X = 6.79 °C, SD 3.23, $\underline{n}$ = 75; Broods X = 9.35 °C, SD = 2.74, $\underline{n}$ = 24; $\underline{P}$ = 0.03).

<u>Nests</u>.--Four nests of 2 radiomarked females and 1 unmarked female were located during the study. Two nests (same female)

were located on canyon walls, 1 was located on the ground at the downstream end of an island, and 1 was in a ground level tree cavity (Cassirer et al. 1993b).

FOOD HABITS

Harlequin ducks eat almost entirely animal matter. During the breeding season they usually feed on insect larvae attached to rocks on the stream bottom. The harlequin bill has a hard edge and a pointed tip adapted to prying food from rocky substrate. Their habit of feeding on chitons and barnacles in the marine environment is 1 indication of their prowess at obtaining securely attached prey. Little work has been done on inland food habits, however there is no evidence of selection for any particular taxa of stream invertebrates (Bengtson and Ulfstrand 1971).

Harlequins will also feed on drifting material, on roe (Dzinbal 1982), and occasionally will take small fish. However, these foods are generally taken opportunistically and are usually secondary to their reliance on benthic material.

Methods

Benthic macroinvertebrate samples were collected on 5 streams used by harlequin ducks and 4 streams not used by harlequin ducks in early June of 1991. Samples were taken again in late June of 1991 and 1992 on the 2 streams where ducklings were successfully produced in 1991.

All macroinvertebrate samples were collected using a 0.1 m^2 Hess sampler. Three samples were collected per site, and 2 sites were sampled per stream. Sites on streams used by harlequin ducks were located in riffles where harlequins were frequently observed, near the upstream and downstream edges of reaches of known use. After collection, samples were immediately transferred to jars and preserved in 90% ethyl alcohol.

Samples were hand-picked and separated into groups of lowest identifiable taxonomy. Ephemeropterans, Plecopterans, and Trichopterans were separated into size classes of less than or equal to 3 mm (nymphules) or greater than 3 mm. Nymphules had not yet developed the morphological characteristics necessary for positive taxonomic identification below the ordinal level. Organisms greater than 3 mm were identified to species where possible except the Chironomidae which are extremely difficult to identify without staining. Chironomid larvae ranged from 2 mm to 8 mm in size with an estimated average size of 5 mm.

Abundance was determined by counting all individuals in each sample. Biomass was determined by placing the preserved specimens in an 80 ^{0}C oven and drying for 24 h to a constant weight. Dried specimens were weighed on an electronic balance to 0.01 g. Because cases constructed of inorganic material (e.g. caddis larvae cases) can contribute 83% to the dry weight of the organism (Collier 1991), all caddis larvae were removed from their cases before biomass estimates were calculated.

Water samples were collected at each site (2 per stream) in

1990 and 1991. Samples were placed in coolers on ice until delivered to the Idaho Dept. of Health and Welfare Water Quality lab for analysis of dissolved $CaCO_3$ and SO_4.

Harlequin duck feces were collected opportunistically from loafing sites. Feces were only collected when the duck was actually observed at the site. One stomach sample was collected from a trap mortality. Feces and stomach samples were preserved in 90% ethyl alcohol.

Diagnostic parts of sclerotized insect pieces in fecal samples were analyzed to family where possible. Other organic and inorganic material was also examined under a dissecting scope. Relative contribution of each taxonomic group and other organic material was visually estimated.

Results and Discussion

At least 33 taxa in 10 orders were represented in the benthic samples. The orders Ephemeroptera, Plecoptera, Trichoptera, and Diptera made up approximately 82% of all taxa encountered in the samples (Gustin 1993, Appendix B). Total standing crop was highly variable, both within and among streams. Average standing crop per stream ranged from 0.22 to 1.06 g/m^2 (Table 8). Average standing crop on streams used by harlequin ducks ($\underline{X}$ = 0.52 g/m2, SD = 0.19, $\underline{n}$ = 5) was greater than that on streams not used by harlequin ducks ($\underline{X}$ = 0.34 g/m^2, SD = 0.13, $\underline{n}$ = 4) however this was not the case on all streams (Table 8) and the difference was not significant ($\underline{P}$ > 0.05).

Table 8. Standing crop (g/m^2) of macroinvertebrates on 9 streams in northern Idaho, 1991 - 1992.

Stream	Harlequin Use	Date	$\bar{x}$	S.D.	min	max
Granite Cr., L. Pend Oreille	Y	7/15/92	1.06	0.18	0.93	1.19
Granite CR., L. Pend Oreille	Y	7/15/91	1.03	0.16	0.92	1.14
Granite Cr., L. Pend Oreille	Y	6/13/91	0.82	0.07	0.78	0.87
Gold Cr., Priest Lake	Y	7/13/92	0.55	0.01	0.54	0.56
Gold Cr., Priest Lake	Y	6/19/91	0.54	0.02	0.53	0.55
Beaver Creek	N	6/27/91	0.53	0.02	0.51	0.54
N. Fork Granite Cr.	Y	6/20/91	0.49	0.31	0.27	0.71
Hughes Fork	Y	6/19/91	0.46	0.03	0.44	0.48
Gold Cr., Priest Lake	Y	7/18/91	0.43	0.03	0.42	0.45
S. Fork Granite Cr.	N	6/27/91	0.31	0.06	0.26	0.35
Caribou Cr.	N	6/24/91	0.30	0.14	0.20	0.40
Gold Cr., L. Pend Oreille	Y	6/14/91	0.29	0.02	0.28	0.30
Lion Cr.	N	6/24/91	0.22	0.02	0.21	0.23

Water Chemistry.--Although there was no significant relationship between macroinvertebrate biomass and harlequin duck use, streams used by harlequin ducks in northern Idaho, western Montana, and northwestern Wyoming were significantly more alkaline ($\underline{X}$ $CaCO_3$ = 58 m/l, $\underline{n}$ = 11) than northern Idaho streams

not used by harlequin ducks ($\underline{X}$ CaCo3 = 8 m/l, $\underline{n}$ = 4, $\underline{P}$ = 0.004) (Table 9).

Fecal Samples.--Harlequin duck fecal samples and stomach sample contained primarily Ephemeroptera (mayflies) and Trichoptera (caddisflies) (Table 10). Other organic material included feathers, plant material, woody particles, conifer needles, and insect cases. In general, although there were far fewer taxa in the fecal samples than in the stream samples, the relative abundance of taxonomic groups in the fecal samples reflected the abundance of those taxa in the streams. However, some taxa, e.g. Lepidostomatidae and Glossosomatidae, were common in the fecal samples, but poorly represented or absent in the stream samples. This might be due to differential digestibility, to differences in the timing of collection of the fecal and benthic samples, and/or to patchy distribution of some taxa which contributed to sampling error in collection of the benthic samples.

Table 9. Alkalinity and sulfates (mg/L) in streams in northern Idaho, northwestern Montana, and northwestern Wyoming sampled in 1990 - 1991.

Stream	Date	Alkalinity ($CaCo_3$)	Sulfate (SO_4)
Berry Cr., Grand Teton N.P.	8/30/90	132	-
Gold Cr., L. Pend Oreille	8/23/90	86	-
Gold Cr., L. Pend Oreille	6/14/91	77	12
McDonald Cr., Glacier N.P.	9/7/90	74	-
Hughes Fork	6/20/91	62	< 5
Granite Cr., L. Pend Oreille	6/13/91	58	< 5
Gold Creek, Priest Lake	6/19/91	44	< 5
N. Fork Clearwater	9/8/90	31	-
N. Fork Granite Cr.	6/19/91	29	< 5
Lochsa River	9/9/91	29	-
St. Joe River	8/21/90	26	-
S. Fork Granite Cr.	6/27/91	19	-
Beaver Cr.	6/27/91	7	< 5
Caribou Cr.	6/24/91	3	< 5
Lion Cr.	6/24/91	3	< 5

Table 10. Percent composition of 17 harlequin duck fecal samples and 1 stomach sample collected on northern Idaho streams, 1991 - 1992.

Sample No.	Ephemeroptera	Trichoptera	Other Insects	Organic Matter	Inorganic matter size class
67	30[a]	45[d]	20 Plecoptera	5	Gravel
68	5[a]	90[d]	0	5	Gravel
69	5[a]	90[d]	0	5	None
70	5[b]	90[e]	0	cases[e (5)]	None
71	0	5[f]	85 Coleoptera	15 (Eggs 5)	None
72	70[a]	20[f]	0	10	None
73	10[a]	80[d]	0	10	Sand and Clay
74	5[a]	85[f]	5 Coleoptera	5	Sand and Clay
75	45[a, c]	45	0	10	Clay
76	90[a, c]	5	0	5	Gravel
77 (Stomach)	80[a, c]	0	0	20 (near Elodea)	None
78	60[b]	30	0	10	Gravel
79	75[b]	20	0	5	None
92	90[a]	0	0	10 (Feather)	Gravel and Sand
93	90[a]	5	0	5	Gravel
94	95[a, b, c]	0	0	5	Gravel
95	0	100[f]	0	0	Gravel and Sand
96	75[a]	20	0	5	Gravel
97	80[a, b]	10	0	10	Gravel

[a] - Ephemerellidae, [b] - Heptageniidae, [c] - Baetidae

[d] - Glossosomatidae, [e] - Brachycentridae, [f] - Lepidostomatidae

INTERACTIONS BETWEEN POPULATION DYNAMICS AND ENVIRONMENTAL FACTORS

Previous studies in harlequin duck breeding areas have demonstrated correlations between harlequin duck productivity and invertebrate biomass (Bengtson and Ulfstrand 1971) and productivity and stream runoff (Kuchel 1977). We examined these factors by comparing stream flows and invertebrate biomass with harlequin duck productivity.

Methods

Stream flows were measured at U.S. Forest Service gaging stations on Upper Priest River and Granite Creek at Lake Pend Oreille. Productivity was compared to monthly stream flows April - August with linear correlation analysis. Benthic macroinvertebrate samples were collected on Granite Creek at Lake Pend Oreille and Gold Creek at Priest Lake in 1991 and 1992. Samples were collected and analyzed as described in the previous section. Samples were collected from the same areas both years.

Results and Discussion

Average productivity was negatively correlated to May, June, and July streamflows. The closest relationship was apparent between June streamflows and productivity ($r = -0.93$, $P = 0.006$). Benthic macroinvertebrate biomass on Gold Creek at Priest Lake and Granite Creek at Lake Pend Oreille did not differ significantly between years (Fig. 1), and harlequin duck

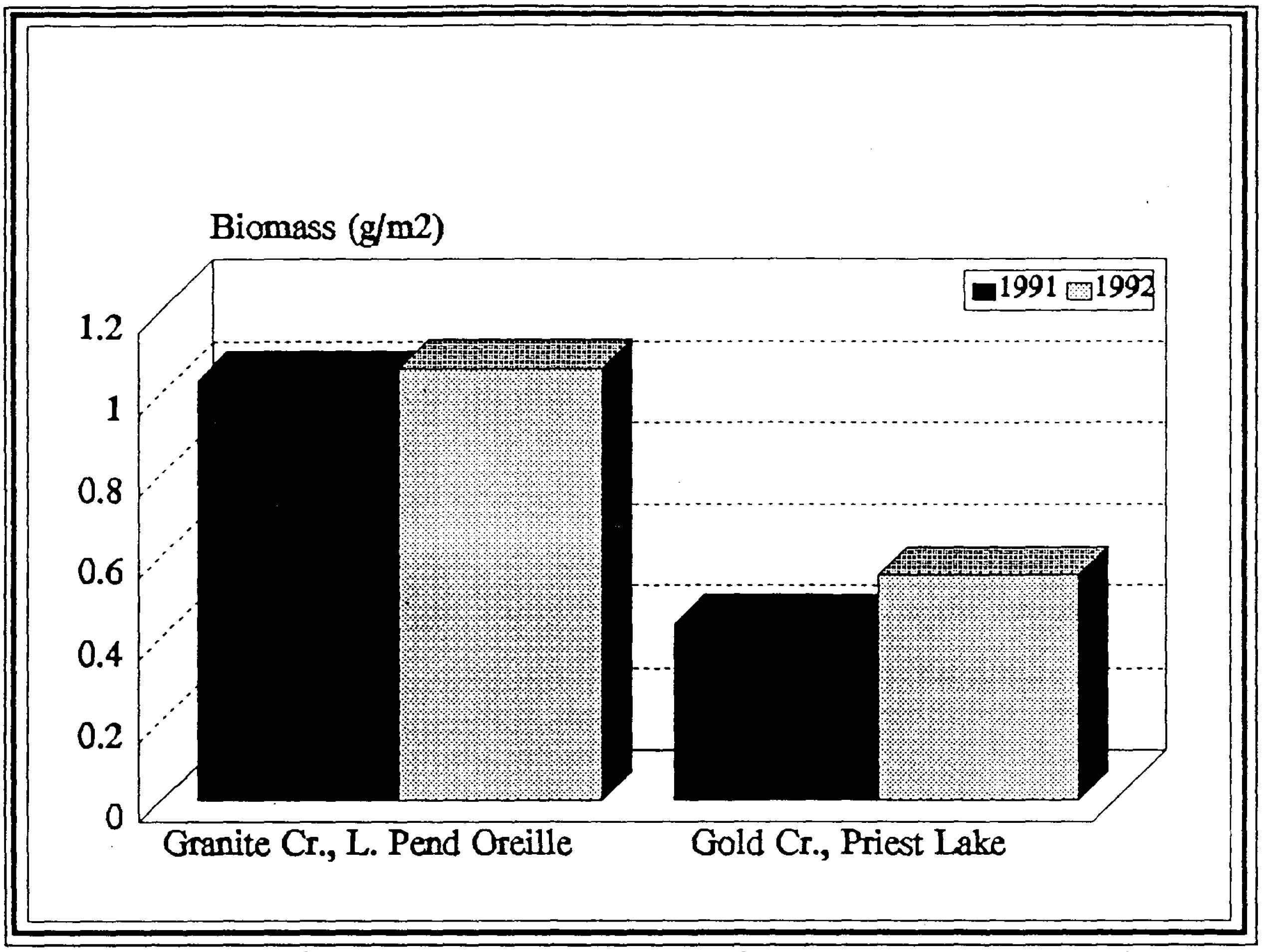

Fig. 1. Benthic macroinvertebrate biomass on 2 harlequin duck breeding streams in northern Idaho, 1991-1992.

productivity was independent of macroinvertebrate biomass ($\underline{P}$ = 0.41).

The data collected in this study support the conclusion of Kuchel (1977) and others (Diamond and Finnegan 1992) that productivity of harlequin ducks in the Rocky Mountains is inversely related to spring runoff. This might be due to destruction of nests along the streambank and/or the inability of newly hatched ducklings to negotiate high water. Although

Bengtson and Ulfstrand (1971) and Gardarsson and Einarsson (1991) documented a relationship between invertebrate biomass and harlequin duck productivity in Iceland, this may be only a secondary consideration, if a factor at all, in the Rocky Mountains. Longer term data would help assess the importance of both factors.

INVENTORY AND MONITORING PROTOCOL FOR HARLEQUIN DUCKS IN NORTHERN IDAHO

Research has documented low numbers of harlequin ducks in northern Idaho, but insufficient data are currently available to adequately determine population trend, or effects of management actions. Annual harlequin duck monitoring conducted for at least 10 years is necessary to establish baseline data and to examine relationships of population size and productivity with environmental factors including stream flows, weather, local management activities, and conditions in coastal areas.

Additionally, although extensive stream surveys have established the overall harlequin duck breeding distribution in northern Idaho (Cassirer et al. 1991), inventory of breeding areas is still incomplete. Inventory should be ongoing to determine the extent of harlequin duck use of streams with unknown status.

These inventory and monitoring guidelines are based on data collected in northern Idaho breeding areas, from the Lochsa River to the Canadian border between 1987 and 1992. Breeding

chronology of harlequin ducks varies by area, for instance harlequin duck arrival and breeding activities in Grand Teton National Park, Wyoming occur 2 - 4 weeks later than in northern Idaho (Wallen 1987). Therefore, this protocol is only specifically applicable to the area it was developed, and other areas where similar breeding chronology has been documented.

Monitoring

Twenty-one northern Idaho streams with documented use by harlequin ducks should be monitored annually (Table 11). Streams currently of unknown status should be added to this list in the future if inventory efforts reveal they are harlequin duck breeding streams. Monitoring should be conducted whether or not any management activites are scheduled in the area. Monitoring also can and should be incorporated in the biological evaluation of any activity conducted on harlequin duck streams during the breeding season (April - September) or any activity conducted outside the breeding season that may alter habitat conditions on the stream during the harlequin duck breeding season.

Inventory

Inventory should be conducted on streams with unconfirmed reports of harlequin ducks; on streams adjacent to or tributaries to streams known to be used by harlequin ducks; and on streams which are potentially suitable harlequin duck habitat as described in Cassirer and Groves (1991). Some streams in

Table 12. Some streams to inventory for harlequin ducks in northern Idaho[a].

Area	Stream	Previous Idaho Conservation Data Center survey dates
KOOTENAI RIVER DRAINAGE	Boundary Creek	August 1989, May and July 1993
	Boulder Creek	July 1990, 1993
	Long Canyon Creek	May and August 1993
	Smith Creek	May and July 1990, July 1993
PRIEST LAKE DRAINAGE	Boulder Creek	May 1992
	Caribou Creek	August 1989, May 1991
	Lion Creek	August 1989, May 1991
	Soldier Creek	June 1987, May 1992
	Trapper Creek	June 1989
	Uleda Creek	
	Two Mouth Creek	May 1991
PACK RIVER DRAINAGE	Grouse Creek	July 1990
COEUR D'ALENE RIVER DRAINAGE	Teepee Creek	May and July 1988
	Independence Creek	May 1987, August 1987
	Pine Creek	
LAKE PEND OREILLE DRAINAGE	Lightning Creek	June and August 1987, May and July 1988
	Trestle Creek	
ST JOE RIVER DRAINAGE	Slate Creek	June 1987, July 1990
	Bussel Creek	
	Mica Creek	July 1988
	Fly Creek	
CLEARWATER DRAINAGE	Bear Creek (Selway)	August 1989, May 1990
	Meadow Creek (Selway)	May 1989
	Whitecap Creek (Selway)	July 1989, May 1990
	S. Fork Clearwater River	May and July 1989
	Crooked River	May 1989

[a] A partial list of inventory needs

Table 12 cont'd. Some streams to inventory for harlequin ducks in northern Idaho[a].

Area	Stream	Previous Idaho Conservation Data Center Surveys
CLEARWATER DRAINAGE cont'd.	Red River	May and July 1989
	Orogrande Creek	July 1988
	Vanderbilt Creek	July 1990
	Weitas Creek	May 1987
	Fish Creek (Lochsa)	May 1987
	Squaw Creek (Lochsa)	May 1993
SALMON RIVER DRAINAGE	Bargamin Creek	
	Ebenezer Creek	

[a] A partial list of inventory needs.

Although this is the period when pairs are most likely to be observed, even when conducted during this period, surveys underestimate the actual number of pairs present by an average of 25 to 35 percent (Fig. 3). Therefore, 2 surveys should be conducted during this period for monitoring purposes. The survey with the highest number of ducks should be used for monitoring estimates.

Although the highest numbers of ducklings are observed in early July (Fig. 2), brood surveys conducted for monitoring purposes should occur between July 15 and August 5. Because of mortality rates typically occurring in young ducklings, this later period gives a more accurate estimate of ducklings fledged (Fig. 3). Ducklings should be aged by plumage development (Fig. 4) during brood surveys.

Table 11. Northern Idaho streams to monitor annually for harlequin ducks.

Stream	Reach
KOOTENAI RIVER DRAINAGE	
Moyie River	Canadian Boundary to Moyie Falls
PRIEST AND UPPER PRIEST LAKE DRAINAGE	
Gold Creek	Hemlock Creek to Hughes Fork
Granite Creek	Willow Creek to Blacktail Creek
Hughes Fork	Hughes Meadows to Upper Priest River
Upper Priest River	Upper Priest Falls to 1013 Bridge
Middle Fork East River	Devil's Creek to Priest River(?)
COEUR D'ALENE RIVER DRAINAGE	
N. Fork Coeur d'Alene River	Marten Creek to Teepee Creek
LAKE PEND OREILLE DRAINAGE	
East Fork Lightning Creek	Thunder Creek to Lightning Creek
S. Gold Creek	Road 278 culvert to Lake Pend Oreille
N. Gold Creek	Branch North Gold to Lake Pend Oreille
Granite Creek	Road 278 crossing to Lake Pend Oreille
ST. JOE RIVER DRAINAGE	
St. Joe River	Heller Creek to Marble Creek
Marble Creek	Cornwall Creek to St. Joe River
Simmons Creek	Road 1278 crossing to St. Joe River

Table 11, cont'd. Northern Idaho streams to monitor annually for harlequin ducks.

Stream	Reach
CLEARWATER RIVER DRAINAGE	
Crooked Fork	Shotgun Creek to Lochsa River
White Sands Creek	Colt Creek to Lochsa River
Lochsa River	White Sands Creek to Boulder Creek
N. Fork Clearwater	Niagara Creek to Kelly Creek
Kelly Creek	N. Fork Kelly Creek to Kelly Forks
Little N. Fork Clearwater	Canyon Creek to Foehl Creek
Selway River	MacGruder to Moose Creek

northern Idaho that remain to be adequately inventoried are listed in Table 12. This list is by no means complete.

Survey Methodology

Timing is critical for both inventory and monitoring surveys. Timing is probably the most important factor in survey success. For this reason, most surveys must be conducted specifically for harlequin ducks, rather than in combination with fish or other wildlife surveys. In northern Idaho, spring pair surveys should be conducted between April 25 and May 25 (Fig. 2).

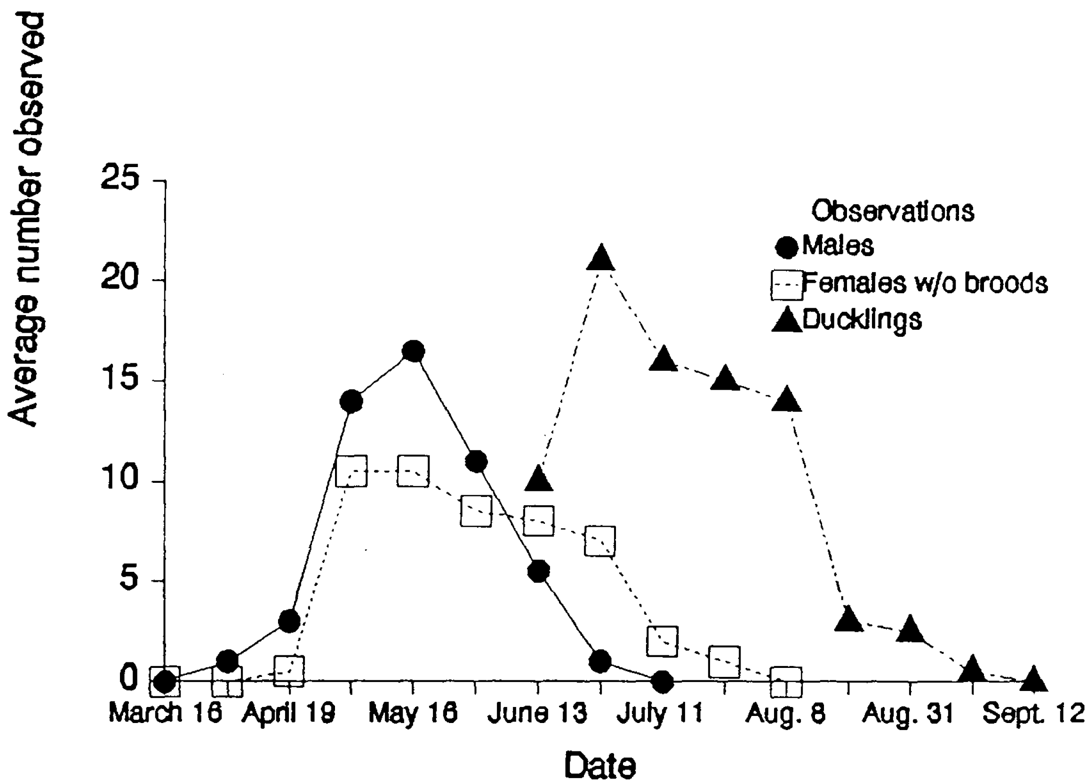

Fig. 2. Timing of harlequin duck observations during surveys on 7 streams in northern Idaho, 1991-1992.

Inventory surveys should cover the entire stream from 2nd- or 3rd-order headwaters to the mouth. Inventory of this area should be conducted during the spring, and again during the summer, (or until ducks are observed, whichever is first) for at least 2 years before determining stream status. Therefore, inventory should be an ongoing program, not simply associated with proposed management activities.

Little specialized equipment is required for harlequin duck surveys. Some equipment that may be useful is:

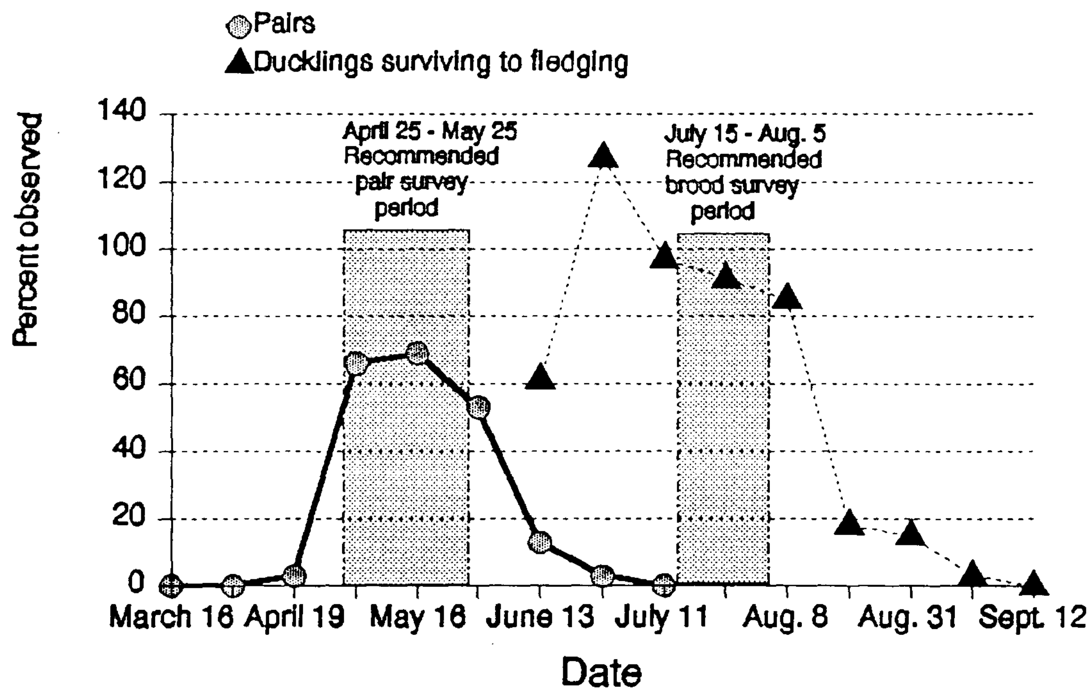

Fig. 3. Estimated accuracy of harlequin duck surveys conducted on 7 streams in northern Idaho, 1991 - 1992.

8 to 10 power waterproof binoculars

Felt-soled wading boots

Neoprene stocking foot chest waders

Surveys can be conducted during any weather and at any time of day. Surveyors should use binoculars as much as practical, particularly in long, straight stream reaches. Harlequin ducks are commonly observed sitting on instream rocks or on the streambank, swimming or feeding in the middle of the stream, or

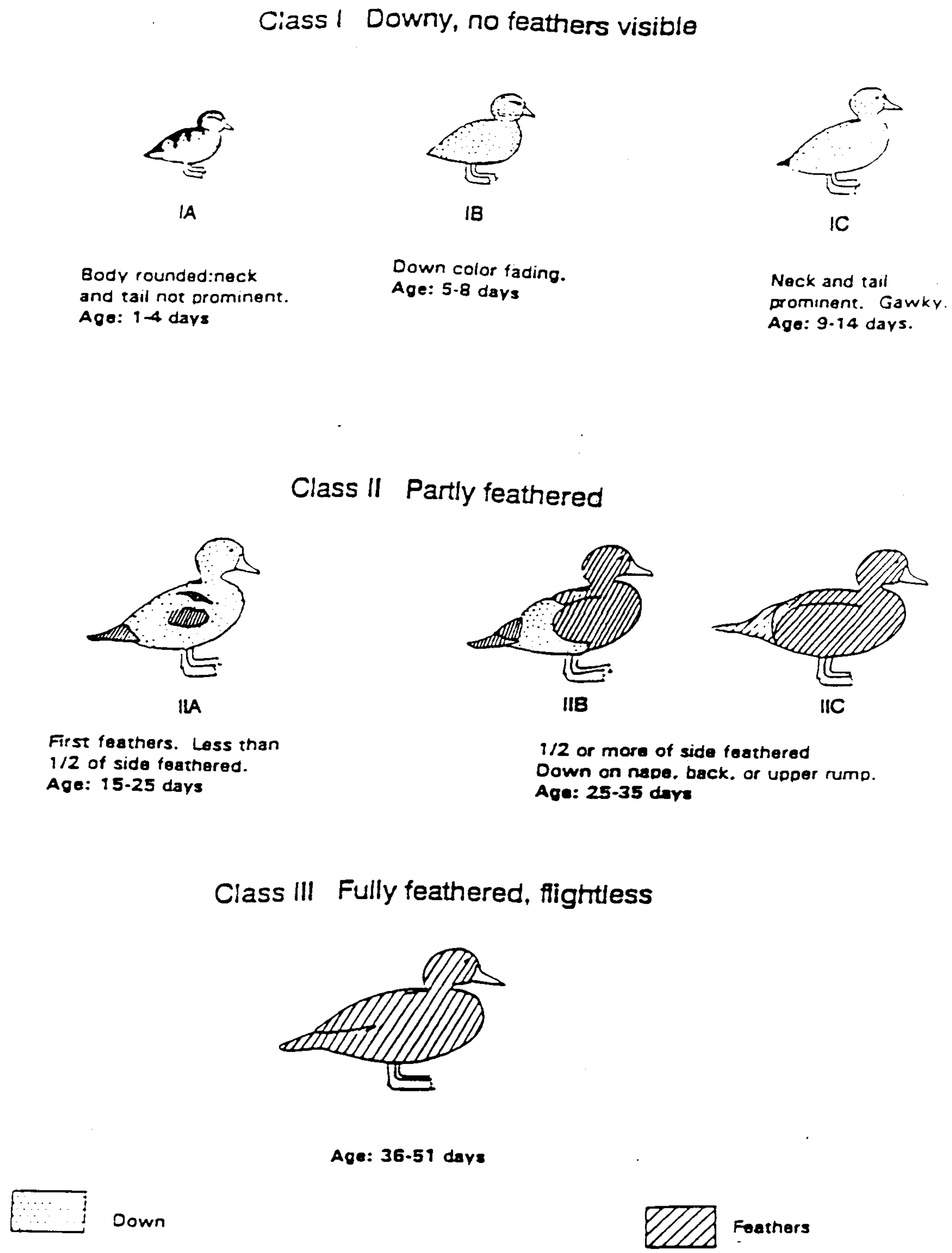

Fig. 4. Guide to aging harlequin ducklings in the field (from diagram in Dimmick and Pelton 1994:173, after Gollop and Marshall 1954).

paddling along the bank eddy. In the spring, the male is usually spotted first. Look carefully for the female nearby, the white spot on the side of her head is usually her most conspicuous feature. Both the male and female appear dark in flight, with no white markings on the underside of the wings. The only other duck in Idaho that may be confused with the harlequin is a female bufflehead. However, the white spot on the side of the head of the bufflehead is not as distinct, the white on the wings is visible during flight, and the bufflehead has light colored legs and feet, while those of the harlequin are dark. Buffleheads are also uncommon on most streams used by harlequin ducks in northern Idaho.

Surveys can be conducted on foot, by boat, or by driving next to the stream. Walking is the best way to survey most streams. Walking surveys can be conducted in an up- or downstream direction. It is easier to survey downstream, however the ducks will not swim as quickly upstream as they float downstream, so for an inexperienced observer they may be more observable when surveys are conducted going upstream. If a road is available, use a crew of at least 2 people. Drop 1 person off at the beginning of the survey reach, a second person drives to a midpoint, preferably where the truck is visible from the stream or at a bridge or trail crossing, and walks to the end of the survey reach. After ducks are observed move off the stream to walk around them. When surveys are conducted in a downstream direction, you can often get closer to the ducks by making a wide

Table 13. Data form for harlequin duck surveys.

HARLEQUIN DUCK SURVEY FORM

Surveyors' names: ______________________________

Address: ______________________________

Date: ____________ Time start: ________ Time end: ________

Stream name: ______________________________

Start location: ______________________________

End location: ______________________________

Distance (km): __________

Type of survey (walk, boat, drive): __________

Observations/comments: ______________________________

Harlequin duck observations

Note: Idaho, Montana, Wyoming and several coastal states and provinces have marked harlequin ducks. Colored nasal markers on the bill, and colored, numbered, and metal legbands on both legs are being used. Please check for marks on all harlequins and include a detailed description of any observed.

Time: ________ Number: _____ Sex: ______ Age class: ________

Location: UTMN ______________ UTME ______________

T______ R________ S________ 1/4________

Activity/comments: ______________________________

____

Time: ________ Number: _____ Sex: ______ Age class: ________

Location: UTMN ______________ UTME ______________

T______ R________ S________ 1/4________

Activity/comments: ______________________________

____

Time: ________ Number: _____ Sex: ______ Age class: ________

Location: UTMN ______________ UTME ______________

T______ R________ S________ 1/4________

Activity/comments: ______________________________

Send copy to:Idaho Fish & Game,Conservation Data Center,Box 25,Boise,ID 83707.

circle around to get below them and approach from downstream. Count on covering about 1 mile per hour in spring surveys and 1.5 miles per hour in summer surveys. Because the ducks are mobile, enough people should be surveying to cover the entire stream in 1 day.

Boating is a very good way to survey, especially in the spring. Rafts or drift boats are best, because 1 person can row while 1 or 2 passengers look for ducks. Fifteen to 20 miles of stream is a reasonable distance to cover by boat in a day, but distance covered will vary with water conditions and access. Kayaking is also a good survey method and may be the only way to cover some streams at certain times of year. Depending on the stream and season, kayakers should be comfortable running class IV or V water and should also be familiar with harlequin ducks. Inner tubes may be used in summer surveys when the water is too low for boating but too deep or swift for walking. A wet suit or neoprene chest waders are usually necessary when inner tubing, even in warm weather.

Driving surveys can be conducted by 2 people along roads that closely follow the stream. Drive slowly with the observer in the passenger side of the vehicle next to the stream or in the back of a pickup. Check areas where the stream is not in full view of the road on foot.

The spring pair survey period coincides with peak spring runoff in northern Idaho. Therefore walking surveys of 4th-order or greater streams will usually be conducted by hiking along the

streambank. Surveyors should be prepared for inclement weather and snow. If roads are not plowed, snowmachines may be necessary to get to survey areas. Camping out may be required to cover the upper reaches of some streams.

Streams will be relatively low during brood surveys and walking surveys can be conducted by a combination of wading in the stream and walking along the bank. Felt-soled boots with neoprene socks and wool socks are recommended for walking in the stream. Stocking foot chest waders with felt-soled boots may be useful in cooler weather or higher water.

Data Collection

Record data on a standardized form (such as the 1 in Table 13), and enter the information into a computer data base. Please send copies of all inventory and monitoring data, even when no ducks are observed, as well as reports on streams not previously known to have harlequins to the Idaho Fish and Game Conservation Data Center.

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Appendix A

Harlequin duck habitat use data sheet

HARLEQUIN DUCK DATA SHEET

DATE__________ TIME__________ STREAM____________________ OBSERVER________

OBSERVATION TYPE- NO.____________ SEX____________ AGE CLASS________________

ACTIVITY LO LOAFING SW SWIMMING SF SWIMMING/FEEDING FL FLYING

OT OTHER Explain____

CIRCLE ONE		CIRCLE ONE PER DUCK		CIRCLE ONE		CIRCLE UP TO TWO	
HABITAT		**LOCATION**		**SUBSTRATE**		**BANK COMPOSITION**	
PO	POOL	BA	BANK	CL	CLAY	TR	TREES
BA	BACKWATER	LO	LOAF	SA	SAND	SH	SHRUB
RI	RIFFLE	EY	EDDY	GR	GRAVEL	GF	GRASS/FORB
RU	RUN	ED	EDGE	CO	COBBLE	MO	TREE/SHRUB MOSAIC
GL	GLIDE	BT	BANK 1/3	BO	BOULDER	SA	SAND
PW	POCKETWATER	CE	CENTER	BE	BEDROCK	SI	SILT
RA	RAPID					GR	GRAVEL
						DE	DEBRIS
						BE	BEDROCK

CIRCLE AS APPROPRIATE

OVERSTORY AGE		**TIMBER MGMT**		**CHANNEL TYPE**		**HUMAN ACCESS**	
SE	SEEDLING	NO	NONE	ME	MEANDER	AD	ADJACENT
SA	SAPLING	CL	CLEARCUT	BR	BRAIDED	NE	NEAR
PO	POLE	ST	SEED TREE	ST	STRAIGHT	AC	ACCESSIBLE
IM	IMMATURE	SW	SHELTERWOOD	CU	CURVED	IN	INACCESSIBLE
MA	MATURE	CT	COMM. THIN				
OG	OLD-GROWTH	SH	SELECTION HARVEST				

DEBRIS / 10 M
ENTER # OF EACH TYPE

LOAFING SITES / 10M____ BANK UNDERCUT Y N

BR BRIDGE____________
CB COLLAPSED BRIDGE___
RA RAMP____________
DR DRIFT____________

STREAM WIDTH (M)______ VEG. OVERHANG Y N

OVERSTORY SPP.______________________________

DENSIOMETER READING______ ______ ______ ______

WATER VELOCITY __________ __________ __________

UTMN______________________ UTME______________________

T____________ R____________ S____________ 1/4____________

MMENTS____

STREAM HABITAT
POOL- deep slow water areas in the stream.
BACKWATER- slow water area out of the main stream channel.
RIFFLE- shallow water areas where the water surface is influenced by the stream bottom.
RUN- deeper than a riffle, no whitewater but velocity greater than 0.3 m/sec, too fast to be a glide or pool.
GLIDE- run areas with velocities < 0.3 m/sec.
POCKETWATER- a run or riffle with boulders (> 30 cm in diameter) which create numerous small pools.
RAPID- deep fast water, water influenced by stream bottom and/or streambank (whitewater).

LOCATION
BANK- on streambank.
LOAF- loafing on rock or log.
EDDY- in an eddy created by a rock or log.
EDGE- at the very edge of the stream next to the bank-in the bank eddy.
BANK 1/3- not directly adjacent to the bank but in the third of the stream closest to the bank, not in an eddy.
CENTER- in the water in the center third of the stream, not in an eddy.

SUBSTRATE
GRAVEL- 0.2-7 cm (0.1"-3") diameter
COBBLE- 8-30 cm (3"-12")
BOULDER- >30 cm

OVERSTORY AGE
SEEDLING- 1-10 years old, < 4.5' tall.
SAPLING- 10-40 years old, > 4.5'tall, DBH <5"
POLE- 40-70 years old, DBH 5"-9".
IMMATURE- 70-100 years old, DBH 9"-14".
MATURE- 100-160 years old, DBH 14"-20".
OLD GROWTH- over 160 years old or DBH > 20".

CHANNEL TYPE
MEANDER- channel follows sinuous curves, deep pools separated by shallow riffles, appears to shift slightly during peak flows.
BRAIDED- channel located in flat bottomed valley, midstream bars occur and divide the stream into several intersecting and shifting channels.
STRAIGHT- stream channel linear, structurally controlled by a "V" shaped valley. No movement of channel during peak flows.
CURVED- stream channel curves or zig-zags more abruptly than a meander. Channel structurally controlled by a "V" shaped valley, no movement during peak flows.

HUMAN ACCESS
ADJACENT-established area of human activity maintained within 10 m.
NEAR- established area of human activity maintained within 10-50 m.
ACCESSIBLE- >50 m from human activity, accessible by boat or trail.
INACCESSIBLE- >50 m from human activity, not accessible by boat or trail.

WOODY DEBRIS
BRIDGE- log across stream.
COLLAPSED BRIDGE- log across stream, submerged in the middle of the stream.
RAMP- one end of log in the stream, the other on the bank.
DRIFT- log floating in stream.

LOAFING SITE- rocks or log in the stream completely surrounded by water, suitable for resting site.

VEGETATIVE OVERHANG-vegetation extending over the stream within 12" of the water surface.

Appendix B

Summary of organisms encountered in 78 benthic samples collected in northern Idaho

Appendix Table B. Summary of organisms encountered in 78 benthic samples collected in northern Idaho, 1991 - 1992.

Class	Order	Family	Genus	Species	Tolerance Value *
Insecta					
	Ephemeroptera				
		Baetidae			4
			Baetis	sp.	
		Ephemerellidae			1
			Drunella	*doddsi*	
			Drunella	*grandis*	
			Ephemerella	*aurivilli*	
		Heptageniidae			4
			Cinygmula	sp.	
			Epeorus	*longimanus*	
			Rhithrogena	robusta	
		Leptophlebidae			2
			Paraleptophlebia	*debilis*	
		Siphlonuridae			7
			Ameletus	sp.	
	Plecoptera				
		Chloroperlidae			1
			Alloperla	*forcipata*	
			Kathroperla	*perdita*	
			Sweltsa	sp.	
		Perlidae			1
			Hesperoperla	*pacifica*	
		Perlodidae			2
			Isoperla	sp.	

Appendix Table B cont'd. Summary of organisms encountered in 78 benthic samples collected in northern Idaho, 1991 - 1992.

Class	Order	Family	Genus	Species	Tolerance Value
Insecta					
	Trichoptera				
		Brachycentridae			1
			Brachycentrus	*americanus*	
		Glossosomatidae			0
			Glossosoma	sp.	
		Hydropsychidae			4
			Parapsyche	*elsis*	
		Limnephilidae			4
			Neophylax	sp.	
			Psychoglypha	*suborealis*	
		Rhyacophilidae			0
			Rhyacophila	*neograndis*	
			Rhyacophila	*verrula*	
	Diptera				
		Athericidae			2
			Atherix	sp.	
		Blephariceridae			0
		Chironomidae			6
		Pelecorhynchidae			N.A.
			Glutops	sp.	
		Simuliidae			6
			Twinna	*tibblesi*	
		Tipulidae			3
			Hexatoma	sp.	

Appendix Table B cont'd. Summary of organisms encountered in 78 benthic samples collected in northern Idaho, 1991 - 1992.

Class	Order	Family	Genus	Species	Tolerance Value
Insecta					
	Coleoptera				
		Elmidae			4
			Dubiraphia	*giullianii*	
tropoda					
	Limnophila				
		Physidae			8 **
Pelecypoda (= Bivalvia)					
		Sphaeridae			8 **
			Pisidium	sp.	
Acarina					
		Hydracarina			4 **
Oligochaeta					
	Limicolae				10 **
Turbellaria					
	Tricladida				
		Planariidae			4 **
			Planaria	sp.	

These values are for use with the biotic index scale of 0-10 with 0 being the least tolerant.

* Hilsenhoff's Family Level Pollution Tolerance Values. Hilsenhoff (1988).

** Tolerance Values for some macrioinvertebrates not included in Hilsenhoff (1988) (EPA/440/4-89/001, 1989).

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